Achieving Carbon Neutrality by 2040

Roadmap for McGill's Energy Transition

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Purpose of the document

In December 2017, following the recommendations of the Advisory Council on Sustainability, McGill's senior administration (the principal and vice-principals) committed to achieving carbon neutrality by 2040. All Scope 1 and 2 emissions as well as material Scope 3 emissions are included in the target. Emissions from building energy use accounted for 66% of McGill's 2015 greenhouse gas inventory, therefore, transitioning McGill's energy systems to low carbon solutions will be key to meeting the University's carbon neutrality target. McGill's Utilities & Energy Management department together with the McGill Office of Sustainability developed a roadmap for the energy transition. Note that initiatives have been identified by the McGill Office of Sustainability to tackle other sources of emissions such as emissions from McGill's fleet of vehicles, emissions from directly-financed air travel, or emissions from commute, but the present document focuses solely on the de-carbonization of McGill's building energy systems.

About carbon neutrality

Carbon neutrality refers to the process of achieving net zero greenhouse gas (GHG) emissions by balancing activities that release emissions with mitigation actions that reduce or negate these impacts. While the term "carbon neutrality" did not exist in 1992 when the United Nations Framework Convention on Climate Change (UNFCCC) was adopted, the key concept of balancing carbon sources – particularly anthropogenic sources – with carbon sinks is embedded in Article 2 of the UNFCCC.

> "The ultimate objective of this Convention…is to achieve…stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[1]

This objective has been the focus of the Conferences of the Parties (COP), a body dedicated to the review and negotiation of climate action. The Paris Agreement, produced from COP21 in December 2015, deals specifically with climate mitigation, adaptation, and financing. One of its main aims is:

> "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."[2]

The Intergovernmental Panel on Climate Change's 5th Assessment Report details the emissions reductions needed to achieve each of the potential warming scenarios, indicating that global neutrality is required well before 2100 to have a likely chance of limiting temperature increase below 2°C[3]. Reduction initiatives are required from all areas – governments, business, institutions, cities, and individuals – in order to achieve the dramatic changes required within this timeframe. McGill's commitment to achieve carbon neutrality by 2040 aligns with – and exceeds – the minimum targets of the global and scientific communities.

Average global emission reduction timelines corresponding to the 2-degree scenario

	By 2050	**By 2100**
Change in CO_2e emissions required to maintain temperature increase below 2°C relative to 1990	*avg. ↓87.5%*	*avg. ↓129%*

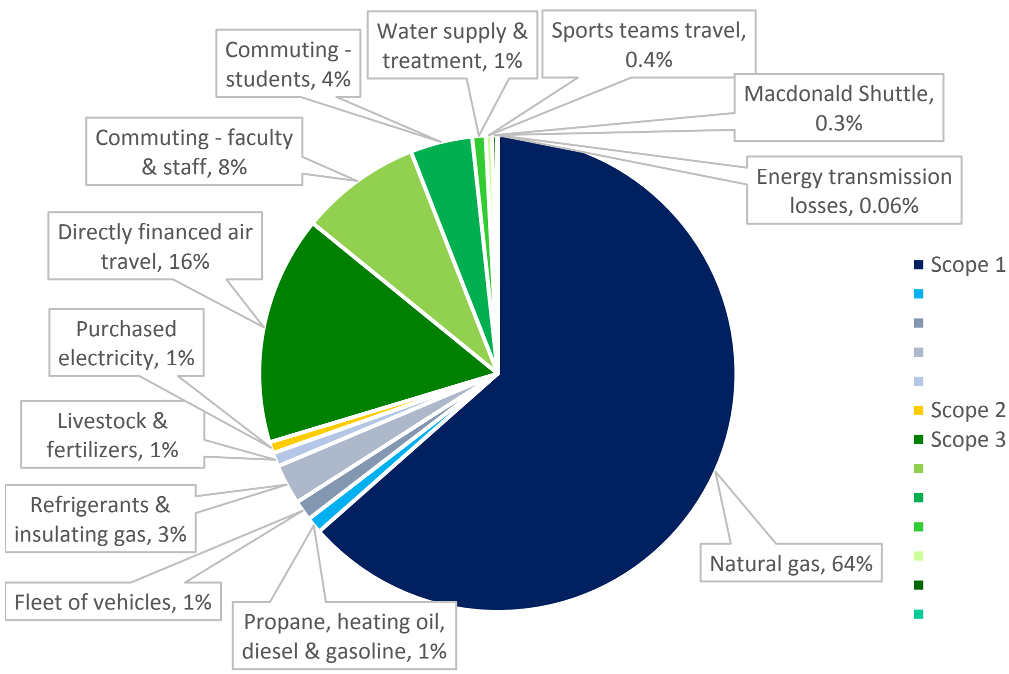
There are three main pathways to achieve neutrality: emission reductions, carbon sequestration, and carbon offsetting. Carbon sequestration can be natural, for instance, via forests and agricultural lands, or through engineering processes, such as carbon capture and storage. Offsets are credits for GHG reductions achieved by one party that are purchased to compensate the emissions of another party. McGill will leverage all of these options to achieve its carbon neutrality target via a diversified approach, prioritizing emissions reduction and sequestration strategies in order to drive long-term change on its campuses.

[1] UNFCCC, United Nations 1992: https://unfccc.int/resource/docs/convkp/conveng.pdf
[2] UNFCCC, United Nations 2015: http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf
[3] Table adapted from Table 3.1 p. 22 of IPCC's AR5: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf

Current overview of emissions

The impact category of importance in the context of achieving carbon neutrality is GHG emissions – specifically, the seven GHGs described in the Kyoto Protocol[4]. In 2015, McGill's most recent inventory, our GHG emissions were 54,062 tCO_2e. Scope 1, 2 and 3 emission sources[5] contributed approximately 70%, 1% and 29%, respectively.

Overview of McGill's 2015 greenhouse gas emissions by scope



As a leader in education and research, McGill is characterized by high energy intensity, research-intensive activities, and a travelling population. Building energy use accounts for 66% of 2015 emissions, and 52% of the energy used in university buildings is from fossil fuels – predominantly natural gas. To achieve carbon neutrality, a transition in McGill's energy systems is of critical importance. To date, emissions from building energy use have decreased 36% since 1990, and the 2016 – 2021 phase of McGill's Energy Management Plan (EMP) includes a 64% GHG reduction target below 1990 by 2021.

Greenhouse Gas Inventory Process

The 2015 inventory was an opportunity for McGill to increase the quality and accuracy of its reporting following recommendations from the review of the 2014 inventory by McGill's Internal Audit department. As such, the 2015 assessment was compiled following the principles of the "GHG Protocol Corporate Accounting and Reporting Standard", an international best-practice standard for organizational GHG assessments developed by the WBCSD/WRI[6]. The 2015 inventory process also included changes to

[4] Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3), HFCs and PFCs

[5] Scope 1: Direct GHGs (emissions from sources that are owned or controlled by the organization);
Scope 2: Energy indirect GHGs (emissions from the consumption of purchased electricity, steam, or other upstream energy generation);
Scope 3: Indirect GHGs (emissions that are a consequence of an organization's operations, but not directly owned or controlled by them).

[6] World Business Council for Sustainable Development/World Resources Institute

underlying methodologies, updates to the 2013 and 2014 inventories in order to better harmonize reporting, and the inclusion of historical base year data for 1990.

Peer analysis

Around the world, the number of organizations taking action on climate change is steadily increasing. Colleges and universities, uniquely positioned to drive progress towards a sustainable future, are announcing emission reduction targets and committing to carbon neutrality goals.

McGill's peer institutions are also taking these actions, with Queen's University in Canada, University of California – Berkeley, and Yale being among those known to have committed to carbon neutrality.

McGill's target of carbon neutrality by 2040 includes our measured Scope 3 emissions. Among the neutrality targets announced as of December 2017, McGill is set to achieve Scope 1, 2 and 3 neutrality ahead of our peers. A comparative analysis of the GHG emissions of selected Canadian and US universities shows that McGill's emissions are larger than comparable universities in Québec, average compared to other Canadian universities, and much smaller than selected research-oriented US universities. This is due in part to the fact that electricity is mainly generated from fossil fuel sources in the US as opposed to Québec, and to a lesser extent Canada, where most of the electricity is from renewable sources.

Examples of mitigation strategies implemented by our peer institutions include energy efficiency measures, electrification of heating systems, on-campus renewable energy installations, voluntary offset mechanisms and community carbon funds, forest carbon sinks, and internal carbon pricing.

Areas of uncertainty

There are both internal uncertainties – those related to McGill's operations and resulting emissions over time – and external uncertainties, which affect the type, feasibility, and cost of mitigation efforts.

Internal Uncertainties

McGill's emissions and emission profile change annually. While some of these changes are minor fluctuations, others relate to the deferred maintenance portfolio and development plans and introduce significant uncertainty into increases in McGill's annual emissions over time. If McGill is successful in acquiring the legacy Royal Victoria Hospital site, there is a huge range in potential impact on emissions depending on whether the development of this site is net zero (or negative) carbon, or low carbon only. As per provincial legislation and McGill's design standards, minimum requirements include that the re-developed buildings use a minimum of 80% renewable energy[7] and be certified LEED silver[8]. Ensuring that LEED certification and construction standards are applied to future real estate developments minimizes the uncertainty around future emission spikes in periods of heavy development.

External Uncertainties

As with the global climate, the climate of Quebec and Montreal is changing – we are experiencing record floods, warmer winters, and melting permafrost at higher latitudes. Median temperatures have already

[7] *Modalités d'application des mesures d'exemplarité de l'État*, Gouvernement du Québec 2016: http://www.transitionenergetique.gouv.qc.ca/fileadmin/medias/pdf/institutions/Mesures_exemplarite_Etat-PACC.pdf

[8] Building Design Standards, Sustainable Design Requirements, McGill University 2017: https://www.mcgill.ca/buildings/files/buildings/mcgill_01_81_13_sustainable_design_requirements.pdf

increased between 1°C to 3°C since the 1950s, and climate models indicate that this is expected to increase by 2°C to 4°C by 2050, and be 4°C to 7°C warmer in parts of the province by the end of the century[9]. Changes in climate translate directly into changes in heating and cooling requirements. While heating demand may decrease by up to 40% over time, cooling demand will increase dramatically – potentially up to 180% – and systems will need to be sustainably designed to handle these realities[10].

Emerging and new technologies and markets will play a key role in achieving carbon neutrality, both in terms of McGill's emissions and in how we reduce them. For example, aviation may see a shift from fossil fuels to electric or renewable energy, resulting in drastically lower emissions intensity from air travel; the electrification of existing public and private transit and the introduction of new options, such as the *Réseau Électrique Métropolitain* or the Hyperloop, would have similar effects. Relatively nascent carbon sequestration technologies and processes are likely to mature and diversify, expanding from the industrial sector and offering new options for anthropogenic carbon sinks. An important area of uncertainty also lies in carbon markets and the future cost of offsets. The cost of carbon offsets is determined by several factors including supply and demand, the offset project type, and the quality of the offset. Quality refers to the accounting and certification mechanisms in place to guarantee the additionality and permanence of the project, and high quality offsets come with higher price tags.

Lastly, current and future federal, provincial, and municipal legislation will affect McGill's neutrality plan. Canada ratified the Paris Agreement in 2016 and communicated an economy-wide target of reducing emissions by 30% below 2005 levels in 2030[11], and 80% below 2005 levels by 2050. Carbon pricing is central to achieving this target. The federal government's Pan-Canadian Framework on Clean Growth and Climate Change from 2016 states that the benchmark carbon price would start at a minimum of $10 per tonne CO_2e in 2018, and rise by $10 each year to $50/tonne CO_2e in 2022[12]. Since Québec already has a legislated cap-and-trade system in place, it is required under this framework to establish a reduction target equal to or greater than Canada's 30% target by 2030 and ensure that annual caps decline to at least 2022. Presently, Québec's target of 37.5% below the 1990 level by 2030 exceeds the federal mandate[13]. Legislation is likely to progress over time, especially within Québec. This being said, there is a risk that the foreseeable decrease in demand in fossil fuel products could result in a downward pressure on the price of fossil fuels, thereby offering an easy way out in the face of possible financial hard times. To ensure that this potential scenario wouldn't negatively impact McGill's target of carbon neutrality, future financial analyses of energy consumption and systems at the University such as the total cost of ownership (TCO) should balance immediate energy costs with non-traditional costs such as offsetting, reputational risk, and the social cost of carbon.

At a municipal level, renewable energy technologies often have a visual impact – solar collectors, photovoltaic panels and even air-source heat pumps are outdoor installations. This poses a challenge in McGill's downtown context where a large portion of the campus falls into historic or environmental

[9] *Vers l'adaptation – Synthèse des connaissances pour les changements climatiques au Québec*, Ouranos 2015: https://www.ouranos.ca/publication-scientifique/SyntheseRapportfinal.pdf

[10] ASHRAE Design Conditions, 2013 ASHRAE Handbook – Fundamentals (SI), ASHRAE, 2013: http://ashrae-meteo.info/places.php?continent=North%20America

[11] http://www4.unfccc.int/ndcregistry/PublishedDocuments/Canada%20First/Canada%20First%20NDC-Revised%20submission%202017-05-11.pdf

[12] https://www.canada.ca/content/dam/themes/environment/documents/weather1/20170125-en.pdf

[13] http://www.mddelcc.gouv.qc.ca/changementsclimatiques/engagement-quebec-en.asp

heritage areas with by-laws influencing the feasibility of these installations; the Macdonald campus and the Bellairs Research Institute are under fewer constraints in this regard.

Closing the gap

In December 2017, following recommendations from the Advisory Council on Sustainability, McGill's senior administration (the principal and vice-principals) committed to achieving carbon neutrality by 2040, a target that includes all emissions from Scope 1 and 2 sources, as well as the majority of material Scope 3 emissions. It was also decided that an intermediate target would be embedded into the neutrality pathway for 2025. The intermediate target was roughly estimated based on the following: implementation timelines within the Energy Management Plan specific to 2025, the assumption that all non-energy initiatives outlined in the gap table below would be at roughly 50% completion by 2025, and holding constant certain emission sources (e.g. T&D losses, water treatment, and refrigerant & insulating gases) for which de-carbonization solutions may not be feasible by 2025.

Establishing an intermediate target ensures that progress is ongoing rather than back loaded, meaning that McGill begins reducing emissions well before the final neutrality date. This is important because McGill will continue to produce emissions each year leading up to 2040, so prioritizing actions for shorter implementation deadlines reduces the overall legacy footprint during this period. A clear intermediate target also helps to keep us aligned with the scientific consensus on de-carbonization timelines, which suggest that emissions need to be roughly halved each decade from now to 2050 to achieve global neutrality.

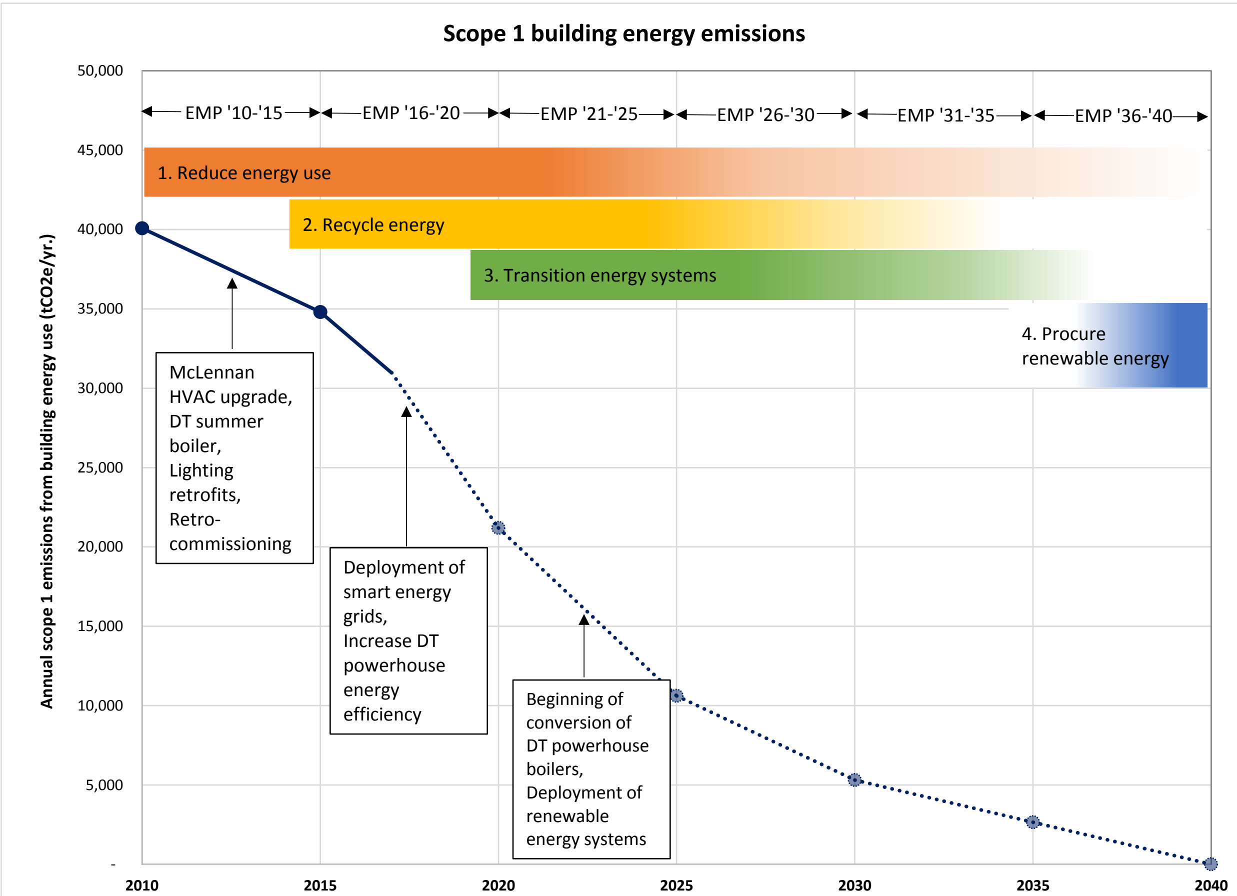
Lastly, as advised by the Advisory Council on Sustainability, McGill's target neutrality date will be revised every three years to take into account the potential to accelerate this timeline due to contributions from external factors such as changes in relevant regulations, available technologies, carbon markets, and climate conditions. Taken together, intermediate targets and ongoing review give our community – and especially cohorts of students who interact with the university on shorter timeframes – more accessible goals for their time at McGill. Ultimately, a sense of connection to and involvement in the plan is vital to its success.

Note that a few of the specific buildings included and excluded from this energy analysis do not align exactly with the scope of the 2015 emissions inventory. Rather, the purpose is to demonstrate that McGill has already started achieving energy and emissions reductions through the implementation of the EMPs. Emissions from building energy were 27% lower in 2016 than in 2010.

Roadmap to de-carbonize energy systems

McGill will follow a tiered approach to de-carbonize its energy systems, as illustrated in the figure below: while maintaining constant efforts to reduce energy use on campus, McGill will deploy heat recovery systems and loops to minimize energy requirements. Once these steps have been taken, the energy transition proper can begin; the selection of an array of low-carbon energy solutions (e.g. ground- and air-source heat pumps, solar thermal collectors, photovoltaic panels, electricity from the grid in Québec, etc.) will be informed by technical economic feasibility analyses in conjunction with a risk assessment of each technology. Indeed, the selection of particular low-carbon solutions must be balanced against the risks they might pose for business continuity. Once the energy transition is completed, there might be an interest in procuring low-carbon energy sources such as renewable natural gas when the commodity becomes more easily available to end-users.

Tiered approach to the energy transition



The table below identifies a number of potential solutions to help close the gap between McGill's 2015 emissions profile and carbon neutrality. Emissions reductions presented herewith are an indication of the potential contribution of each solution towards carbon neutrality; they are not to be read as absolutes. Indeed, we might determine that some solutions are more desirable than others after running in-depth technical economic feasibility analyses and risk assessments.

Actions required to achieve potential GHG emissions reductions by 2040, by emissions source and sink

Emissions Source or Sink	Action Required to Achieve Emission Reductions	Potential Estimated Annual Impact on Emissions in 2040 (tCO_2e)
Building Energy Use – Scopes 1 + 2 – Emissions Source		
Natural gas, heating oil, propane and electricity consumption	Ongoing implementation of the existing energy management plan, taking into account additional energy requirements from the Real Estate Master Plan	-35%
	Continued investment in energy conservation to reduce energy intensity	-3%
Energy use from all building-related projects	Apply energy efficiency requirements of the McGill Design Standards at inception of any project and, where feasible, integrate renewable energy systems into the project where the payback is <=10 years	-1%
Energy use from all major re-development & development	Design projects with carbon neutral energy systems, particularly the RVH and Powell	-1%
Energy use at the Gault Nature Reserve and Bellairs Research Institute	Convert energy systems at both locations to 100% renewable energy	-0.5%
Energy use at the Macdonald Campus	Convert energy systems to 100% renewable energy	-4%
Natural gas consumption at the downtown campus	Replace boiler #2 at the downtown powerhouse with an electric boiler instead of a natural gas boiler	-19%
	Assess technical feasibility to maximize solar thermal collectors and work with appropriate authorities (internal and external) to ease requirements	-2%
	Assess feasibility to install geothermal wells downtown at Lower Field, Middle Field, Forbes Field, and the Molson Stadium	-8%
	Replace another boiler at the downtown powerhouse with an electric boiler instead of a natural gas boiler	-6%
	Procure renewable natural gas for remaining natural gas consumption	-16% *(or balance)*
Natural gas consumption in satellite buildings	Convert to a combination of air-source heat pumps and electricity at the end of equipment lifetime	-5%

Conclusion

Achieving carbon neutrality, and more specifically, decarbonizing McGill's energy systems, is a tangible, timely goal that acknowledges and quantifies McGill's shared responsibility in transitioning the world to a low-carbon future. Future iterations of McGill's Energy Management Plan will bring about the energy transition. The selection of low-carbon energy solutions will be informed by in-depth technical economic feasibility analysis in conjunction with risk assessment.

Other building-related emissions will likely prove difficult or impossible to eliminate, such as emissions from water supply and treatment; electricity consumption, transmission and distribution losses from Québec grid electricity; and refrigerants and insulating gases. Once all potential reduction options are explored and implemented, any remaining emissions will need to be addressed via offsetting, whether through increased carbon sequestration on McGill's managed lands or the purchase of offsets in voluntary or certified markets. Research into the sequestration potential of McGill's lands is underway and, once complete, will determine whether McGill's land assets can be proactively managed to act as carbon sinks. It is important to note that chosen de-carbonization pathways should always take the goals and objectives of the McGill community into consideration.